Claims

1. A method of forming an optical device comprising the steps of:

   - providing a substrate comprising a first electrode capable of injecting or accepting charge carriers of a first type;

   - forming over the first electrode a first layer that is at least partially insoluble in a solvent by depositing a first semiconducting material that is free of cross-linkable vinyl or ethynyl groups and is, at the time of deposition, soluble in the solvent;

   - forming a second layer in contact with the first layer and comprising a second semiconducting material by depositing a second semiconducting material from a solution in the solvent; and

   - forming over the second layer a second electrode capable of injecting or accepting charge carriers of a second type

   wherein the first layer is rendered at least partially insoluble by one or more of heat, vacuum and ambient drying treatment following deposition of the first semiconducting material.

2. A method according to claim 1 wherein at least one of the first and second semiconducting materials is a polymer.

3. A method according to claim 1 or 2 comprising the step of heating the first layer prior to deposition of the second layer.

4. A method according to any one of claims 1 to 3 comprising a step prior to forming the second layer of washing the first layer with a washing solvent in which the first semiconducting material is soluble.

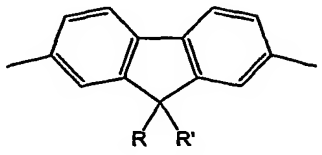
5. A method according to any preceding claim wherein the first layer is deposited from a solution in the solvent.

6. A method according to any preceding claim wherein the solvent is an aromatic hydrocarbon.

7. A method according to claim 6 wherein the solvent is an alkylated benzene.

8. A method according to claim 7 wherein the solvent is toluene or xylene.

9. A method according to any claim 2 wherein the polymer is a polyfluorene comprising optionally substituted repeat units of formula (I):



(I)

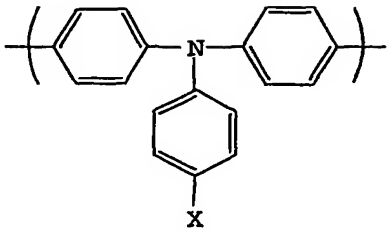
wherein R and R' are independently selected from hydrogen or optionally substituted alkyl, alkoxy, aryl, arylalkyl, heteroaryl and heteroarylalkyl, and at least one of R and R' is not hydrogen.

10. A method according to claim 9 wherein at least one of R and R' comprises an optionally substituted C_4-C_{20} alkyl group.

11. A method according to any preceding claim wherein the first electrode is capable of injecting holes and the second electrode is capable of injecting electrons.

12. A method according to claim 11 wherein the first semiconducting polymer comprises triarylamine repeat units.

13. A method according to claim 12 wherein the triarylamine repeat units are selected from optionally substituted repeat units of formulae 1-6:



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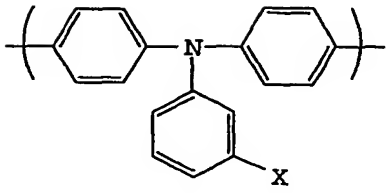

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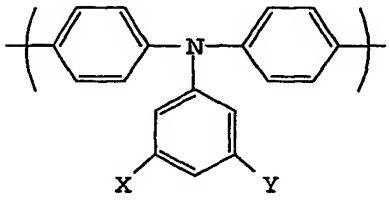

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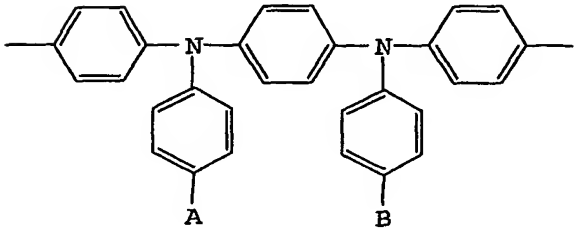

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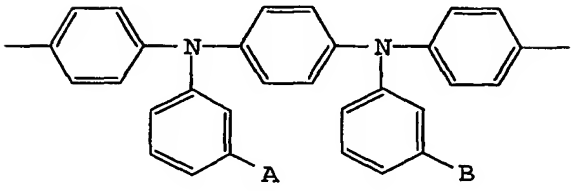

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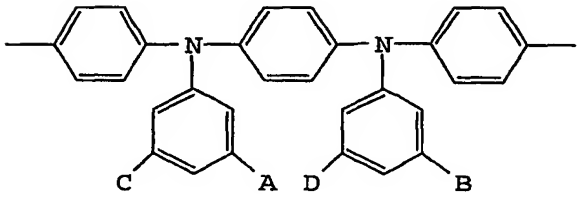

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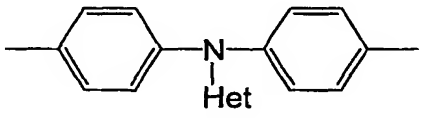
wherein X, Y, A, B, C and D are independently selected from H or a substituent group.

14. A method according to claim 13 wherein one or more of X, Y, A, B, C and D is independently selected from the group consisting of alkyl, aryl, perfluoroalkyl, thioalkyl, cyano, alkoxy, heteroaryl, alkylaryl and arylalkyl groups.

15. A method according to claim 12 wherein the triarylamine repeat unit is an optionally substituted repeat unit of formula 7:



7

wherein Het is a heteroaryl.

16. A method according to claim 15 wherein Het is 4-pyridyl.

17. A method according to any preceding claim wherein the first semiconducting polymer comprises a 1:1 regular, alternating copolymer of a fluorene repeat unit as defined in claim 9 or 10 and a triarylamine repeat unit as defined in any one of claims 12-16.

18. A method according to any one of claims 11-17 wherein a layer of conductive organic material is provided between the first electrode and the first layer.

19. A method according to claim 18 wherein the layer of conductive organic material is PEDT / PSS.

20. A method according to any preceding claim wherein the first layer has a thickness of less than 20 nm.

21. A method according to claim 20 wherein the first layer has a thickness less than 10 nm, preferably in the range 3-10 nm.

22. A method according to any preceding claim wherein the second semiconducting polymer comprises a plurality of regions and comprising at least two of a hole transporting region, an electron transporting region and an emissive region.

23. A method according to claim 22 wherein the second semiconducting polymer comprises a hole transporting region, an electron transporting region and an emissive region.

24. A method substantially as described herein with reference to the drawings.

25. An optical device preparable according to the method of any one of claims 1-23.

26. An organic electroluminescent display preparable according to the method of any one of claims 1-23.

27. A blue light emitting electroluminescent display preparable according to the method of any one of claims 1-23.

28. A white light emitting organic electroluminescent display preparable according to the method of any one of claims 1-23..

29. An optical device comprising, in sequence:

- a substrate

- a first electrode capable of injecting or accepting charge carriers of a first type

- a first layer having a thickness less than 20 nm comprising a first semiconducting polymer that is insoluble in a solvent

- a second layer in contact with the first layer comprising a second semiconducting polymer that is soluble in the solvent

- a second electrode capable of injecting or accepting charge carriers of a second type.

30. A method of forming an optical device comprising the steps of:

- providing a substrate carrying a conductive organic material capable of injecting or accepting holes and capable of donating protons;

- forming over the conductive organic material a first layer by depositing a first semiconducting polymer capable of accepting protons wherein the semiconducting polymer is, at the time of deposition, soluble in a solvent;

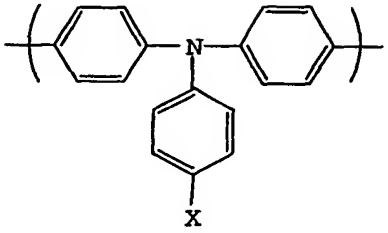
- subjecting the first layer to one or more of heat, vacuum or ambient drying treatment treatment;

- forming a second layer by depositing over, and in contact with, the first layer a second semiconducting polymer from a solution in the solvent; and

- forming over the second layer a second electrode capable of injecting or accepting electrons.

31. A method according to claim 30 wherein the first semiconducting polymer comprises triarylamine repeat units.

32. A method according to claim 31 wherein the triarylamine repeat units are selected from repeat units 1-6:



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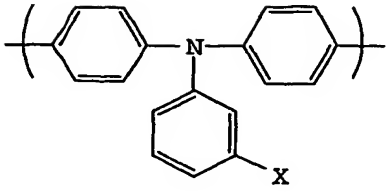

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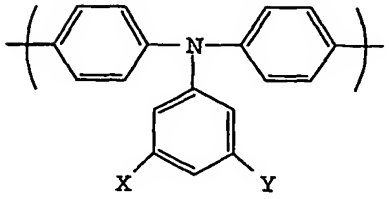

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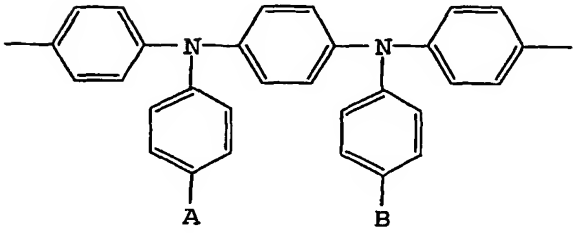

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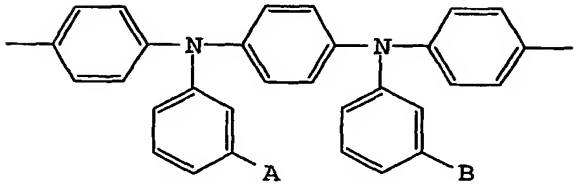

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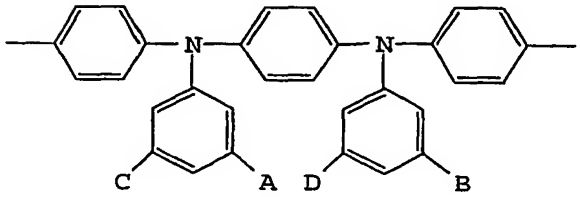

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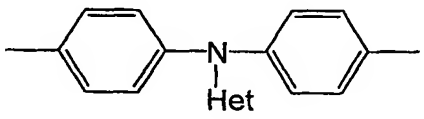
wherein X, Y, A, B, C and D are independently selected from H or a substituent group.

33. A method according to claim 32 wherein one or more of X, Y, A, B, C and D is independently selected from the group consisting of alkyl, aryl, perfluoroalkyl, thioalkyl, cyano, alkoxy, heteroaryl, alkylaryl and arylalkyl groups.

34. A method according to claim 31 wherein the triarylamine repeat unit is an optionally substituted repeat unit of formula 7:



7

wherein Het is a heteroaryl.

35. A method according to claim 34 wherein Het is 4-pyridyl.

36. A method according to claim 30 wherein the first semiconducting polymer comprises a 1:1 regular, alternating copolymer of a fluorene repeat unit and a triarylamine repeat unit.

37. A method according to claim 30 wherein a layer of inorganic material capable of injecting or accepting holes is provided between the substrate and the conductive organic material.

38. A method according to claim 30 wherein the conductive organic material is PEDT / PSS.

39. A method of forming an optical device comprising the steps of:

- providing a substrate comprising a first electrode capable of injecting or accepting charge carriers of a first type;
- forming over the first electrode a first layer that is at least partially insoluble in a solvent by depositing a first semiconducting material that is free of cross-linkable vinyl or ethynyl groups;
- subjecting the first layer to heat treatment;
- forming a second layer in contact with the first layer and comprising a second semiconducting polymer by depositing a second semiconducting material from a solution in the solvent; and
- forming over the second layer a second electrode capable of injecting or accepting charge carriers of a second type.

40. A method of forming an optical device comprising the steps of:

- providing a substrate comprising a first electrode capable of injecting or accepting charge carriers of a first type;
- forming a first layer over the first electrode by depositing a first semiconducting polymer comprising fluorene repeat units, the first semiconducting polymer being free of cross-linkable vinyl or ethynyl groups and being, at the time of deposition, soluble in a solvent;
- subjecting the first layer to one or more of heat, vacuum or ambient drying treatment treatment;

- forming a second layer in contact with the first layer and comprising a second semiconducting polymer by depositing a second semiconducting polymer from a solution in the solvent; and

forming over the second layer a second electrode capable of injecting or accepting charge carriers of a second type.